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(54) **Liquid crystal display device.**

(57) A liquid crystal display device containing an X-Y matrix type liquid crystal display panel in which M pcs. ($M > 1$) of signal electrodes and N pcs. ($N > 1$) of scanning electrodes are arranged in a matrix, the liquid crystal display device comprising a device for reversing the polarity of the voltage waveform applied to the liquid crystal display panel at intervals of n ($1 < n < N$) horizontal scanning periods and for setting the reversing timing at random for every predetermined number of frames, say, every two frames.

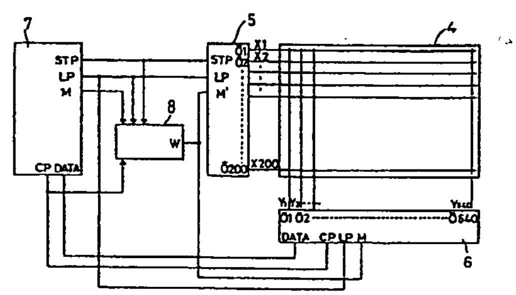

Fig. 1

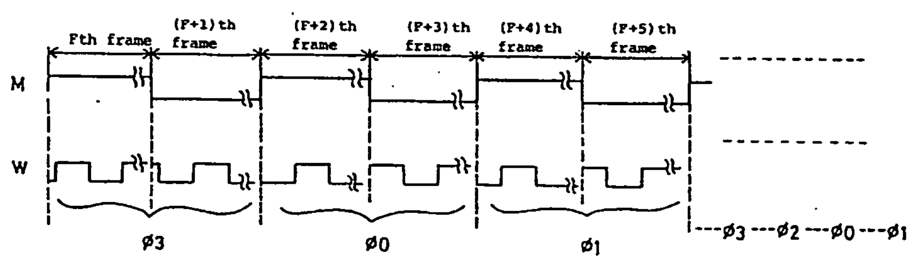

Fig. 5

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LIQUID CRYSTAL DISPLAY DEVICE

Background of the Invention

The present invention relates to a liquid crystal display device containing an X-Y matrix type liquid crystal display panel.

Conventionally, an X-Y matrix type liquid crystal display panel is driven in either of the following two well-known methods: so-called A method in which the polarity of applied voltage is reversed in one horizontal scanning period as shown in Fig. 6, and so-called B method in which the polarity of applied voltage is reversed for each frame as shown in Fig. 7. The waveforms shown in Figs. 6 and 7 include waveform distortion caused by the electrostatic capacity of the liquid crystal panel and by the resistance of the transparent electrodes. The A method provides a smaller ratio of waveform frequency variation by display pattern than the B method does (the frequency change ratio is 2 in the A method whereas it is N in the B method when the duty ratio is N), but provides higher frequency in general, resulting in larger power consumption. Besides, with a larger liquid crystal display panel in which the liquid crystal capacity and the electrode resistance increase, the A method is influenced significantly by waveform distortion so that the effective applied voltage drops. Because of this reason, the A method is hardly used for large liquid crystal display panels.

Presently, therefore, an X-Y matrix type liquid crystal display panel is driven mostly by the B method. For a large high density liquid crystal panel in which the number of time divisions exceeds 100, however, the B method tends to cause irregular picture and crosstalk which deteriorates the picture quality seriously.

Fig. 8 shows a typical crosstalk phenomenon. It is shown that a pattern where black portions 2 should be normally displayed against the white background 1 suffers crosstalk so that portion 3 which should be white become gray. The driving waveforms for the portions 1 and 3 are shown in Figs. 9(1) and 9(2), respectively. In the waveform of Fig. 9(1), that is, in the portion 1 in Fig. 8, the driving frequency component by the display pattern is mainly low frequency, whereas in the waveform of Fig. 9(2), that is, in the portions 3 in Fig. 8, the driving frequency component by the display pattern is mainly high frequency. The difference in the frequency component of the driving waveforms results in a conspicuous crosstalk phenomenon. In other words, crosstalk can be caused by the diversified frequency characteristic of the threshold voltage of the liquid crystal display panel or by the variation of effective voltage caused by distorted driving waveform.

The former cause occurs when the threshold voltage of the liquid crystal display panel changes in a driving frequency band although the effective voltage is constant. The driving frequency band varies depending upon the driving method. As mentioned above, the frequency variation ratios of the conventional A and B methods are 2 and N (N is a duty ratio), respectively. When the threshold voltage of the liquid crystal display panel changes with frequency, the A method is advantageous over the B method in terms of the crosstalk phenomenon because the driving frequency variation ratio is smaller in the A method. On the other hand, the A method has a disadvantage of larger power consumption.

A driving method from which the above problems are eliminated has been proposed. The proposed method is to reverse the polarity of driving voltage applied to the liquid crystal display panel at intervals of specified horizontal scanning periods. According to this method, the advantage of the B method can be made use of, while power consumption is minimized. To explain this method, the driving waveforms in which the polarity of the waveforms of Figs. 9(1) and 9(2) is reversed every four horizontal scanning periods (4H) are shown in Figs. 10(1) and 10(2), respectively. In these waveforms, the frequency of polarity reversing signal is the major component of the driving frequency, so that the influence by the frequency by display pattern is reduced. Namely, in this method, the driving frequency having a low frequency component near the frame frequency is shifted to the higher frequency side so as to contract and equalize the driving frequency component for each picture element. Moreover, the waveform distortion is also equalized as shown in Fig. 10, and the effective voltage value is levelled to some extent in this method.

The above proposed method has an effect of reducing crosstalk phenomenon. But it has another problem that linear display irregularity is generated along the scanning lines when polarity is reversed. This display irregularity is caused by the following reason.

Figs. 11(1) through 11(5) show examples of driving waveforms in the liquid crystal display device. In these figures, waveform distortion caused by the electrostatic capacity of the liquid crystal panel and by the resistance of the transparent electrodes is also taken into account.

Figs. 11(1) and 11(2) show the waveform of

driving voltage applied to the scanning electrodes. The waveform of Fig. 11(1) is for the case where a selection pulse is generated immediately after the reversal of polarity, and the waveform of Fig. 11(2) is for another case. Fig. 11(3) shows the waveform of driving voltage applied to the signal electrodes. This waveform is for the case where all picture elements are turned off. Fig. 11(4) shows the potential difference between the waveform of Fig. 11-(1) and that of Fig. 11(3), and Fig. 11(5) shows the potential difference between the waveform of Fig. 11(2) and that of Fig. 11(3). Both are the waveforms of voltage applied to the picture elements. As shown, waveform distortion is different between Fig. 11(4) and Fig. 11(5). This difference in the waveform distortion causes a uniform effective voltage to be applied to picture elements, resulting in the linear display irregularity. This problem can be solved by shifting the polarity reversing point by 1H (one horizontal scanning period) in each frame to equalize the waveform distortion in each scanning line, thereby making the effective voltage uniform. In this case, however, a driving frequency component smaller than the frame frequency is produced. This results in meandering display irregularity which occurs in the downward direction on the screen during the sequential scanning.

As mentioned above, crosstalk occurs in the conventional liquid crystal display device, and if measure is taken to eliminate the crosstalk, linear display irregularity or meandering phenomenon is observed on the screen.

Summary of the Invention

Accordingly, an object of the present invention is to provide a liquid crystal display device capable of producing a uniform and high quality display.

Another object of the present invention is to provide a liquid crystal display device driving method which realizes a uniform and high quality display free from crosstalk, display irregularity and meandering phenomenon.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

To achieve the above objects, according to an embodiment of the present invention, a liquid crystal display device comprises an X-Y matrix type liquid crystal display panel in which M pcs. of signal electrodes (M > 1) and N pcs. of scanning electrodes (N < 1) are arranged in a matrix, and means for reversing the polarity of the voltage applied to the liquid crystal display panel at an interval of n horizontal scanning period (1 < n < N) as well as for setting the reversing timing at random at an interval of the predetermined number of frames.

In the liquid crystal display device of the above construction, the driving frequency is independent of the display pattern and governed by the frequency of a polarity-reversing signal. In addition, the polarity reversing timing changes at randam every predetermined number of frames, say, every two frames, so that the effective voltage values on the scanning lines are levelled.

Brief Description of the Drawings

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention and wherein:

Fig. 1 is a block circuit diagram of the liquid crystal display device of an embodiment of the present invention;

Fig. 2 is a chart of signal waveforms in the essential parts thereof;

Fig. 3 is a circuit diagram showing in detail the polarity-reversal control circuit shown in Fig. 1;

Fig. 4 is a waveform chart of signals supplied to various parts of the circuit shown in Fig. 3;

Fig. 5 is a chart for explaining one of the signals shown in Fig. 4; and

Figs. 6, 7, 8, 9, 10 and 11 are the drawings explaining the conventional liquid crystal display device.

Detailed Description of the Embodiments

According to an embodiment of the present invention, a liquid crystal display device contain an X-Y matrix type liquid crystal display panel comprising a pair of insulating substrates with a liquid crystal layer sandwitched therebetween, N pcs. of scanning electrodes provided on the inner side of one of the insulating substrates, M pcs. of signal electrodes provided on the inner side of the other substrate, the scanning electrodes and the signal electrodes crossing each other at a right angle. In the following description, it is assumed that N is

200 and M is 640, although the numbers for M and N are not limited to these.

Referring to Fig. 1 which shows the embodiment of the invention, an X-Y matrix type liquid crystal display panel 4 (hereinafter referred to simply as a liquid crystal panel) comprises a liquid crystal layer placed between a pair of insulating substrates, scanning electrodes X_1, X_2, ... X_{200} formed on the inner side of one of the pair of insulating substrates, and signal electrodes Y_1, Y_2, ... Y_{640} formed on the inner side of the other insulating substrate, the scanning electrodes crossing the signal electrodes. Here, the insulating substrate may be made of a conducting member with insulating film applied thereon, or made of a conducting member alone. Insulating films are provided on the signal electrodes and scanning electrodes. 5 is a scanning electrodes driver, and 6 is a signal electrode driver. A controller 7 supplies the drivers 5 and 6 with specified signals. Specifically, the controller 7 outputs display data DATA, dot clock pulse CP for taking the display data and latch pulse LP to the signal electrode driver 6. When 640 dot clock pulses CP have been output to take the data for one line in the signal electrode driver 6, the latch pulse LP is output, making the signal electrode driver 6 latch the data for one line. The signal electrode driver 6 outputs 640 liquid crystal-driving signals on the basis of the latched data. In the present embodiment of the invention, it is assumed the latch pulse is output every one horizontal scanning period (1H) as shown in Fig. 2.

The controller 7 outputs start pulse STP and latch pulse LP to the scanning electrode driver 5. Using the latch pulse LP as a clock pulse, the scanning electrode driver 5 shifts the selection waveform sequentially. The period required for outputting 200 latch pulses LP to complete selection of all the scanning electrodes is one frame. One frame is normally set at 50 to 60 Hz.

A polarity reversal control circuit 8 generates a reversal control signal W which reverses the polarity of the voltage waveform applied to the liquid crystal panel 4 at an interval of n ($1 < n < 200$) horizontal scanning lines and which changes the reversing timing at random every predetermined number of frames, say, every two frames. Start pulse STP, latch pulse LP, dot clock pulse CP and alternating signal M are supplied from the controller 7 to the polarity reversal control circuit 8. The alternating signal M is a binary signal which reverses for each frame, as shown in Fig. 2.

The B driving method uses an alternating signal M whose polarity reverses for each frame. The A method uses an alternating signal M whose polarity changes for each 1/2 horizontal scanning period. Conventionally, the alternating signal M is supplied as it is to the scanning and signal electrode drivers 5 and 6. In the liquid crystal display device of the present invention, the alternating signal M is changed into a reversal control signal W by the polarity reversal control circuit 8 before being supplied to the drivers 5 and 6. The reversal control signal W output from the polarity reversal control signal 8 reverses its polarity at n = 4H (4 horizontal scanning periods) interval in each frame, and the polarity of the signal W at the beginning of each frame is opposite to that at the beginning of the preceding frame. The reversal control signal W provides four different phases ϕ_0, ϕ_1, ϕ_2, ϕ_3. Reversal control signal W of one of the four phases is selected at random at an interval of predetermined number of frames, say, of two frames. This irregularity or randomness of the phase contributes to the uniform display free from crosstalk. The reversing period need not be limited to 4H.

Fig. 3 shows a specific example of the polarity reversal control circuit 8. Referring to Fig. 3, the polarity reversal control circuit 8 comprises a random number generating circuit 9, a latch circuit 10 for storing the output from the random number generating circuit 9 for predetermined number of frames, say, for two frames, a frequency dividing counter 11 which starts counting by reading the initial value at an interval of the predetermined number of frames, say , two frames, an exclusive OR circuit 12 which generates a reversal control signal W by taking the exclusive OR between the output from the frequency dividing counter 11 and an alternating signal M, a first circuit 13 for supplying clock signals S_1 to the latch circuit 10, and a second circuit 14 for supplying operation signals S_2 to the frequency dividing counter 11. The first and second circuits 13 and 14 contain first and second D flip flops 15 and 16, respectively.

The random number generating circuit 9 comprises an oscillator 17 which oscillates by itself at nearly the same frequency as the horizontal scanning frequency, and a quaternary counter 18 which divides the output from the oscillator 17 into four. The quaternary counter 18 comprises third and fourth D flip flops 19 and 20. The quaternary counter 18 sets the polarity reversing period "n" at 4H. When a decimal counter is used instead of the quaternary counter 18, n is set at 10H. However, since the polarity reversing period set by the quaternary or decimal counter is determined by the frequency of the self oscillator 17, the value for "n" can be changed as desired.

In addition to the function of determining the value for "n", the random number generating circuit 9 has a function of generating "n" kinds of phase (four kinds when n = 4H, and 10 kinds when n = 10H). This second function is based on the self oscillator 17 which oscillates by itself at a certain appropriate frequency, independent of the

signal systems of the controller 7. The output from the quatemary counter 18 of the random number generating circuit 9 is retained by a signal S_1 in the latch circuit 10 at an interval of predetermined number of frames, say, two frames. The output thus retained is further latched by a signal S_2 in the frequency dividing counter 11. The frequency dividing counter 11 generates a signal for reversing polarity at 4H intervals. The exclusive OR circuit 12 generates a polarity reversal control signal W by taking the exclusive OR between the output from the frequency dividing counter 11 and an alternating signal M from the controller 7. The signal W is supplied to the input terminals M and M' of the drivers 5 and 6 to change the driving voltage at random.

The signal waveform at each part of Fig. 3 is shown in Fig. 4. The waveform of a polarity reversal control signal W is shown in comparison with that of an alternating signal M in Fig. 5. Fig. 5 indicates that a polarity reversal control signal W of the phase ϕ_3 is generated for the Fth and (F+1)th frames, a polarity reversal control signal W of the phase ϕ_0 for the (F+2)th and (F+3)th frames, and a polarity reversal control signal W of the phase ϕ_1 for the (F+4)th and (F+5)th frames at random. The polarity reversal control signal W of each phase is reversed in its polarity for each frame so as to enable alternating drive which helps lengthen the life of the liquid crystal. This reversal of the polarity is realized by the function of the exclusive OR circuit 12.

As a result, driving voltage, whose polarity is reversed regularly at intervals of n horizontal periods in each frame at a timing which changes randomly every predetermined number of frames, say, every two frames, is applied to the liquid crystal cells constituting the liquid crystal panel.

An embodiment of the present invention has been described above. All the other components than the polarity reversal control circuit 8 shown in Fig. 1 are conventional ones. Therefore, the liquid crystal display device of the present invention is realized easily by connecting the polarity reversal control circuit 8 to an existing system.

According to the present invention, as described above, since the waveform of the voltage applied to the liquid crystal panel (namely the liquid crystal-driving voltage) is reversed in its polarity at intervals of a plurality of scanning lines in each frame, the driving frequency change ratio is small, and the driving frequency component is independent of the display pattern and dominated by the frequency of a polarity-reversing signal. Consequently, crosstalk is hardly generated. Moreover, since the polarity reversing timing is set at random for every predetermined number of frames, say, every two frames, the effective voltage values on the scanning lines are equalized. Therefore, the present invention is extremely effective in producing a picture free from linear display irregularity attributed to the polarity reversal and therefore free from the meandering irregularity.

In the above embodiment, the interval of changing the polarity-reversing timing is two frames, although it need not be limited to two frames. The polarity-reversing timing may be changed at any intervals of a plurality of frames.

The above description is based on the assumption that the number of scanning electrodes is 200 and the number of signal electrodes is 640. These figures for the numbers of electrodes may be changed as desired. These numbers of electrodes may be considered to be provided in the effective display region.

While only certain embodiments of the present invention have been described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit and scope of the present invention as claimed.

There are described above novel features which the skilled man will appreciate give rise to advantages. These are each independent aspects of the invention to be covered by the present application, irrespective of whether or not they are included within the scope of the following claims.

Claims

1. A liquid crystal display device containing an X-Y matrix type liquid crystal display panel in which M pcs. ($M > 1$) of signal electrodes and N pcs. ($N > 1$) of scanning electrodes are opposed to each other in a matrix, said liquid crystal display device comprising means for reversing the polarity of the voltage waveform applied to the liquid crystal display panel at intervals of n ($1 < n < N$) horizontal scanning periods and for setting the reversing timing at random for every predetermined number of frames.

2. The liquid crystal display device of claim 1, wherein said means is a polarity reversal control circuit comprising a random number generating circuit, a latch circuit for storing the output from said random number generating circuit for every predetermined number of frames, a frequency deviding counter which starts counting by reading the initial value for every predetermined number of frames, and a control signal output circuit which outputs a polarity reversal control signal on the basis of the output from said frequency dividing counter.

3. The liquid crystal display device of claim 1, wherein said predetermined number of frames is two frames.

4. A liquid crystal display device according to any preceding claim wherein said reversing and setting means is operable every said predetermined number of frames to select at random one of a plurality of possible polarity reversal control signals of different phases.

5. A liquid crystal display device according to claim 4 wherein said reversing and setting means is operable to effect said polarity reversing in accordance with a said randomly selected polarity reversal control signal during a said predetermined number of frames, but to invert the polarity reversing between successive frames of said predetermined number of frames.

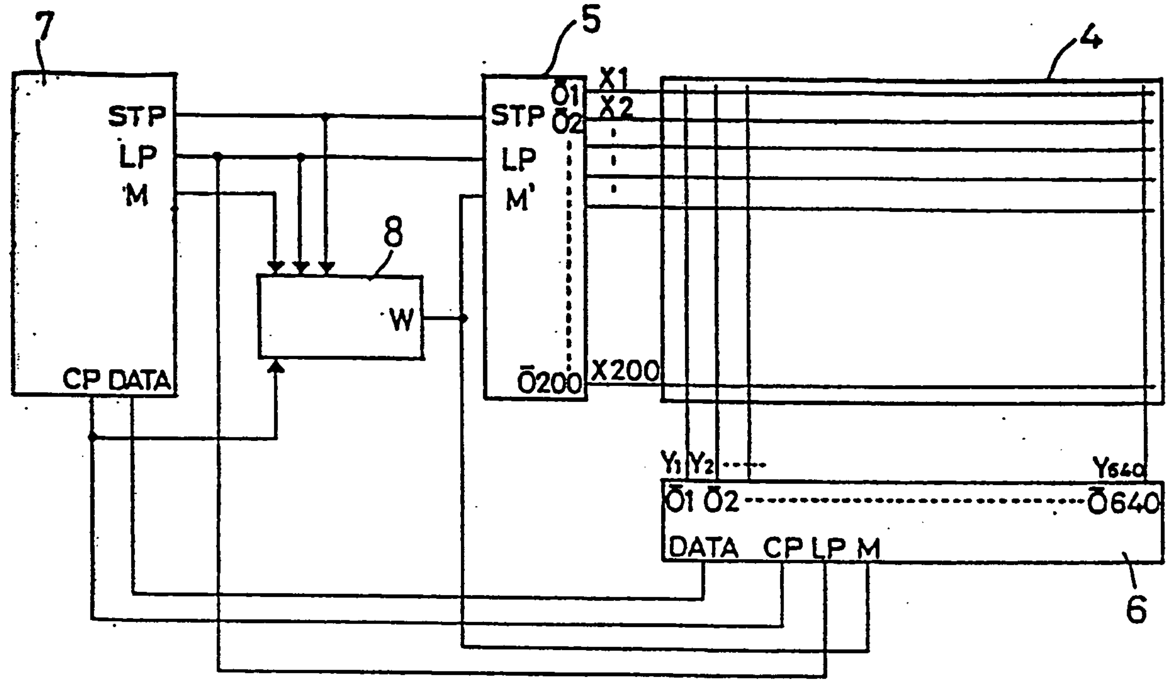

7
STP
LP
M
CP DATA
8
W
5
STP
LP
M'
Ō1
Ō2
Ō200
X1
X2
X200
4
Y1 Y2
Y640
Ō1 Ō2
Ō640
DATA CP LP M
6

Fig. 1

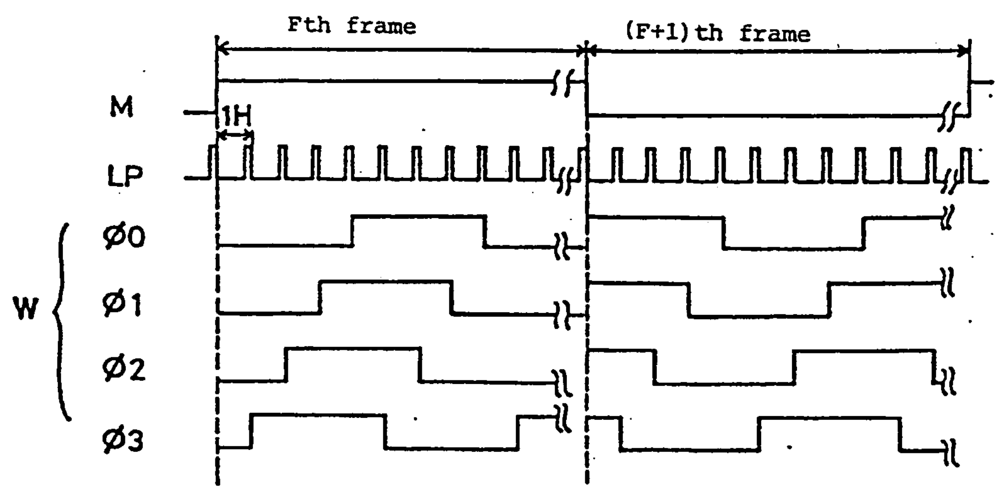
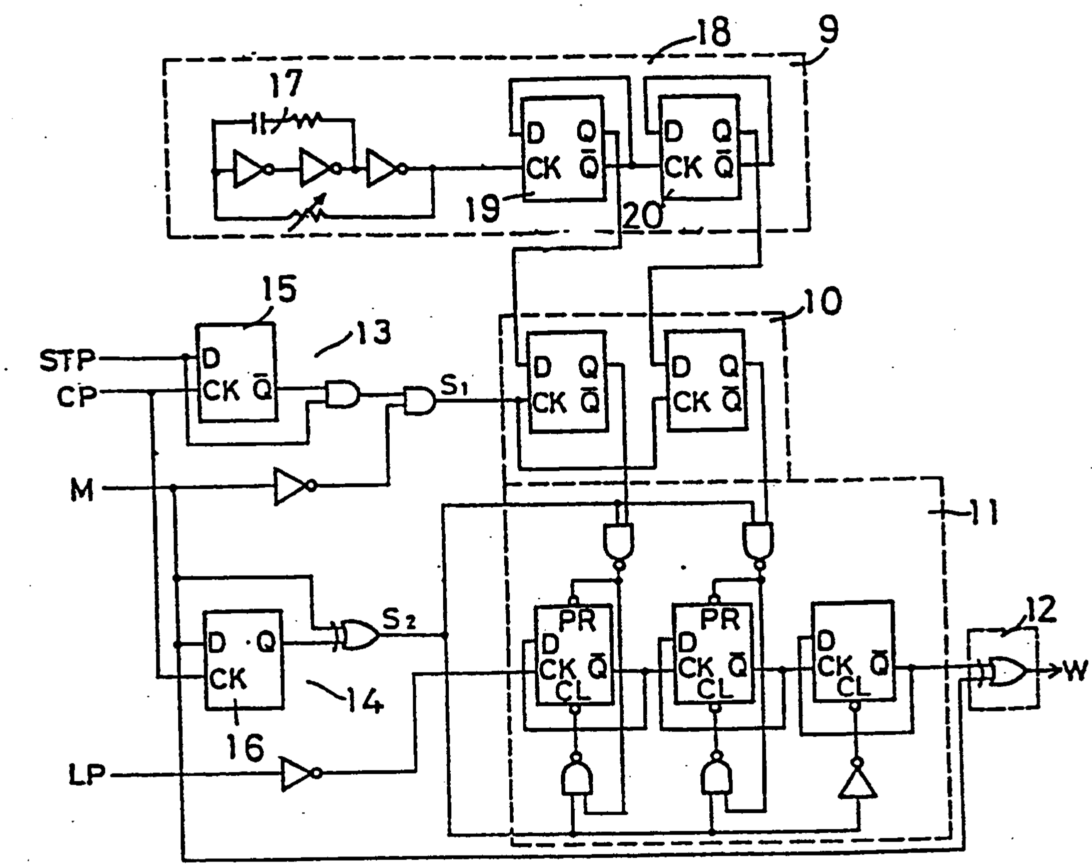

Fth frame
(F+1)th frame
M
1H
LP
Ø0
Ø1
Ø2
Ø3
W

Fig. 2


18
9
17
D Q
CK Q̄
D Q
CK Q̄
19
20
15
13
10
STP
CP
D
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D Q
CK Q̄
D Q
CK Q̄
M
11
S2
D Q
CK
14
PR
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PR
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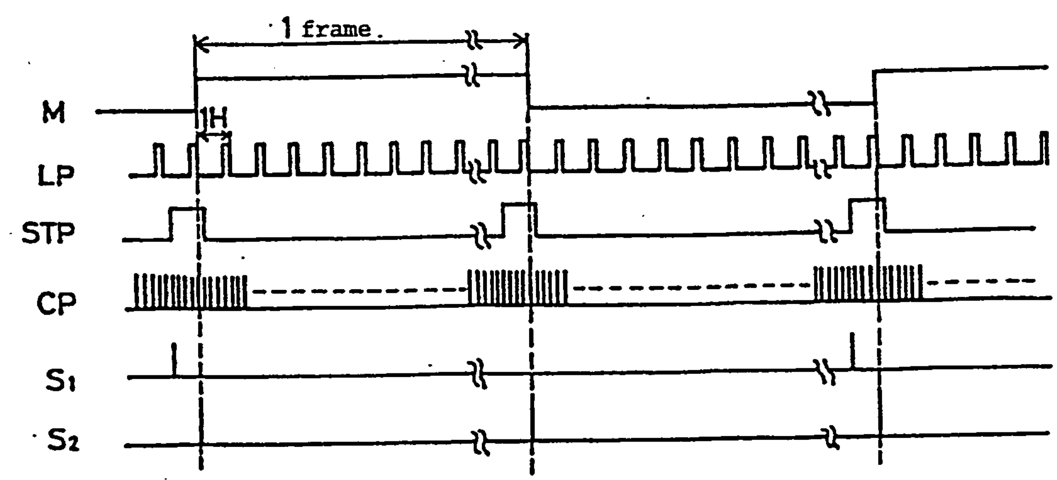
CL
D
CK Q̄
CL
12
W
16
LP

Fig. 3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M
1H
LP
STP
CP
S1
S2

Fig. 4

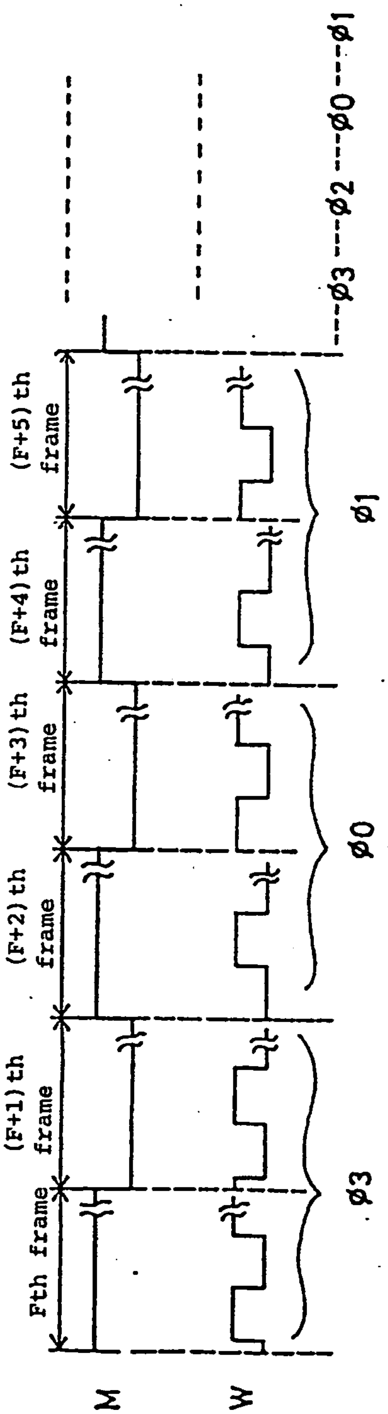
M
W
Fth frame
(F+1) th frame
(F+2) th frame
(F+3) th frame
(F+4) th frame
(F+5) th frame
ø3
ø0
ø1
ø3 --- ø2 --- ø0 --- ø1

Fig. 5

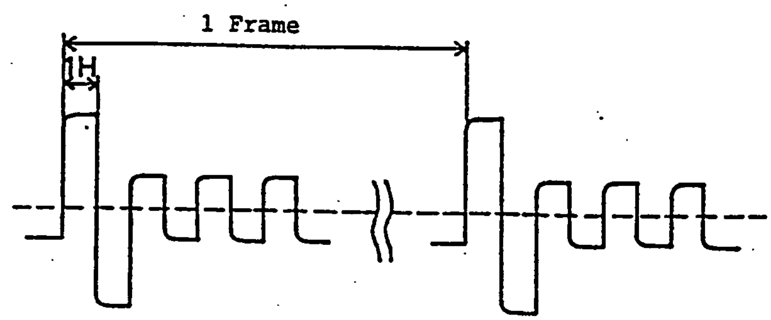

Fig. 6

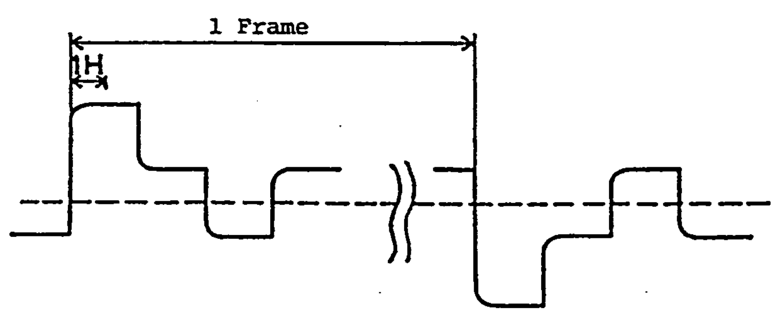

Fig. 7

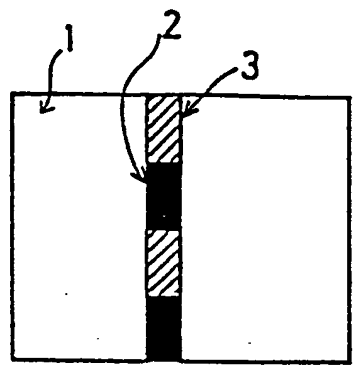

Fig. 8

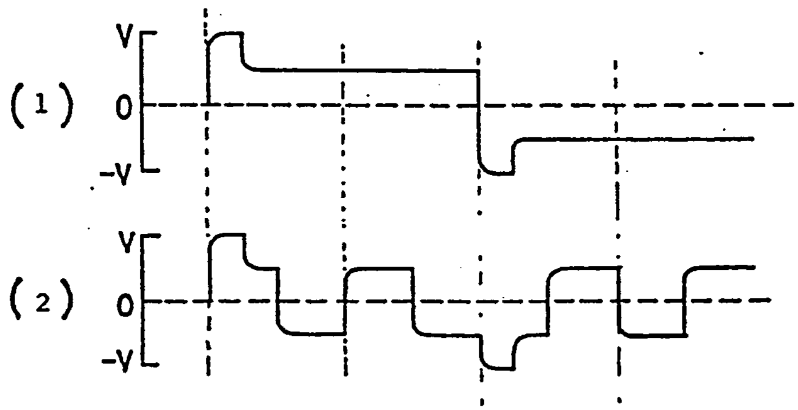

Fig. 9

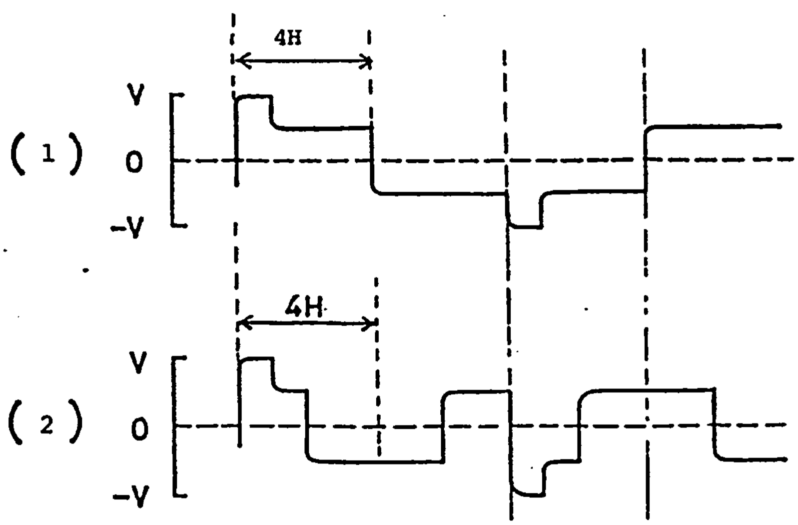

Fig. 10

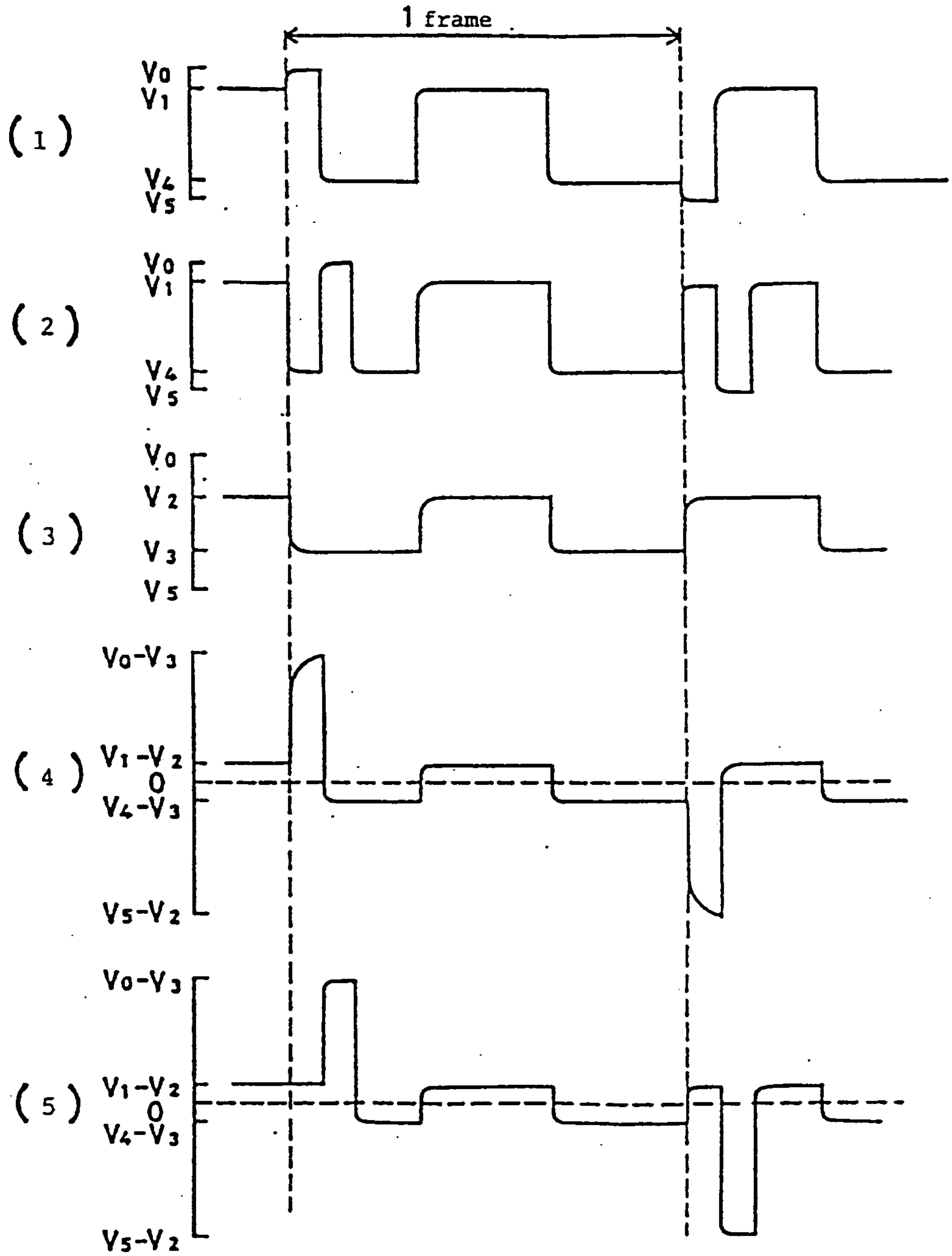
1 frame
(1)
V0
V1
V4
V5
(2)
V0
V1
V4
V5
(3)
V0
V2
V3
V5
(4)
V0-V3
V1-V2
0
V4-V3
V5-V2
(5)
V0-V3
V1-V2
0
V4-V3
V5-V2

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number

EP 88 30 4847

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	CH-A- 645 473 (VIDELEC) * whole document * ---	1	G 09 G 3/36 H 04 N 3/12
Y	EP-A-0 216 168 (CANON) * abstract; claims 1-3,7,8; figures 1,2 * ---	1	
A	PATENT ABSTRACTS OF JAPAN, volume 9, no. 181 (E-331), 26th July 1985; & JP - A - 60 052 166 (MATSUSHITA) 25-03-1985 ---		
A	EP-A-0 020 027 (NATIONAL RESEARCH DEVELOPMENT) * abstract; page 4, line 13 - page 5, line 17; page 9, line 29 - page 10, line 39; page 13, line 22 - page 15, line 24; figures 1,4 * -----	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

H 04 N 3/00
G 09 G 3/00
G 02 F 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	23-09-1988	BEITNER M.J.J.B.

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